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CONSIDERATIONS REGARDING THE ERGONOMICS OF THE VEHICLE INTERIOR

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Abstract

The evolution of the vehicle industry, as well as the sudden increase in competition between manufacturing companies, dictates the increase in the obligations of manufacturers to meet the increasingly complex requirements of users, in terms of ergonomics, comfort, safety, as well as environmental protection. Researchers have investigated the factors influencing the ergonomics of the vehicle interior which is very practical to improve safety and driving performance in addition, it can significantly reduce the development costs and the development cycle of new vehicle concepts, but the concept of ergonomics was not clearly articulated from a human perspective. This study aims to interpret the definition of ergonomics in the context of the interior of the vehicles and also in the study the influencing factors of the ergonomics of the index layer of the human-machine interaction interface, in the central console of the vehicle, are identified. The influencing factors are analyzed by creating and visualizing bibliometric networks in VOSViewer.

Key words: vehicle interior, ergonomics, influencing factors, bibliometric networks, VOSViewer, vehicle industry.

1. Introduction

The need for ergonomics worldwide is recognized by more and more specialists, since the middle of the 20th century, the constitution of ergonomics being the effect of several causes, and at the same time, the cause of new orientations in some older sciences [1].

Analyzing the specialized literature, it can be stated that, at the present time, on a global level, it is manifested by significant progress in an upward trend in the field of ergonomics, as well as structural changes in its concerns. The themes addressed by ergonomics, of a general nature, are maintained at an approximately constant general level, which attests to the concerns sustained in the direction of consolidating the theoretical and methodological basis of ergonomics as an essential condition for its development in the future, through the establishment of various international ergonomics congresses on the themes : the need to strengthen the scientific basis of ergonomics; past present and future in ergonomics; ergonomics in the digital age, the legal framework of the application of ergonomics..etc [2,3,4].

Ergonomics finds, through the goals and the material with which it works, a very wide and open, interdisciplinary horizon, which is concerned not only with the relations between man and the work tool, but

also with the improvement of these relations. In the latter context, ergonomics represents the study of work with the aim of improving it. In the documents of the International Labor Organization it is stated that "Ergonomics is the application of biological, human sciences, in correlation with technical sciences, in order to reach an optimal mutual adaptation between man and his work, the results being measured in indices of efficiency and health well-being of man". The object of study of ergonomics is "the organization of human activity in the work process by optimizing the relationship in the man-machine-environment system, with the aim of increasing technical-economic efficiency, optimizing the conditions of satisfaction, motivation and work results, simultaneously with maintaining good physiological and favoring personality development"[5].

In conclusion, ergonomics is a science that encompasses a series of principles closely related to the improvement of working conditions, of sciences such as: anthropometry, technical sciences, sociology, work psychology, economic sciences, medical sciences, work psychology and other sciences (fig. 1). According to Prof. dr. in ergonomics M.de Montmollin none of the previously listed sciences can claim ergonomics as its appendix [6].

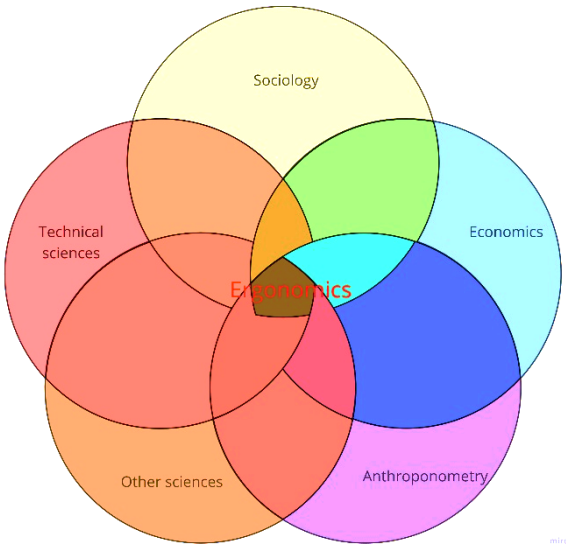

Fig. 1: The interdisciplinary model of ergonomics [6]

Ergonomics deals with the examination of working conditions in order to obtain a better harmony between man and the environment in which he works, also obtaining optimal conditions of efficiency and comfort, in the conception of L.J.F. Alvarez. This prioritizes the protection and comfort of the employed person, the ethics of ergonomics, claims that the best possible working conditions can be improved without neglecting the other criteria. The ergonomics triangle expresses in a synthetic and suggestive form the meaning and identity of ergonomics, so that ergonomics is defined by increasing the results of ergonomics in terms of performance and effectiveness; increasing the level of safety and health through prevention, and increasing comfort and satisfaction through design [6].

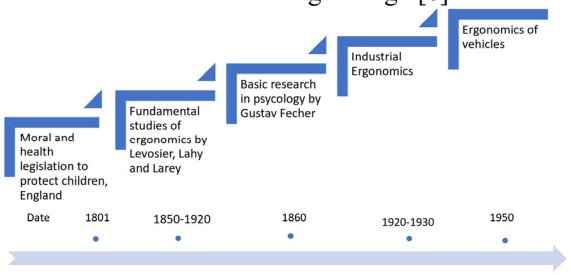

Fig. 2: Diagram of the first discoveries in ergonomics

The first attempts to regulate working conditions came from England in 1802 with the Morals and Health Act to protect children. The literature mentions fundamental ergonomic studies between 1850 and 1920 by Lavoisier, Lahy and Marey, as well as basic research in physiology by Gustav Fechner in 1860. Industrial ergonomics was established in the 1920s and 1930s, and automotive ergonomics developed from 1950 [7].

Vehicle interior ergonomics represents human engineering as a complex scientific field of measures designed interdisciplinary, regarding the mutual and continuous adaptation of both the human factor and the vehicle to the occupational environment inside the vehicle, but also in the driving process. The introduction of ergonomic measures in the automotive industry must not only have the economic purpose of increasing work productivity, but also the purpose of improving driving conditions and increasing passenger satisfaction.

2. Identifying the influencing factors of vehicle interior ergonomics

The ergonomic quality of the vehicle interior is related to the quality of the relationship between the user and the vehicle during its use and is directly related to comfort and safety, being a result of the interaction of the ergonomic characteristics of the vehicle interior with specific users and under specific conditions of use. Ergonomic quality is not a measurable quantity, but a scale of ergonomic quality can be defined by comparing the reaction of users to the ergonomic characteristics of the vehicle [8].

The development of market ergonomics and the continuous development of the car manufacturing industry have made the time spent inside cars to know a special extent. In these conditions, new requirements appear for the components of the work process, for the human factor, for the passenger compartment of the vehicle and for the entire "man-machine-environment" system [9,10].

Ergonomics influences the design of vehicles from the very first stages of their design and, in particular, of the design of the passenger compartment. Major vehicle manufacturers are

investing inexhaustible resources of time and money to meet the increasingly complex requirements of users, regarding the interior environment of vehicles, which are increasingly complex systems. The ergonomics of the interior cabin are among the current performance requirements of vehicles. Determining the factors that influence the ergonomics of the interior cabin is of particular importance in order to take the necessary measures regarding ensuring the ergonomic requirements.

By building the bibliometric networks in the VOSViewer software and analyzing the research databases on ensuring the ergonomics of the vehicle cabin, it was possible to create a scale of the influencing factors. The obtained results are compiled in a database and analyzed. The visualization of the bibliometric networks established in the VOSViewer software can be seen in figure 3. Figure 3 shows an ensemble image of the data presented in detail in Figure 4.

Fig. 3: Viewing bibliometric networks in VOSViewer

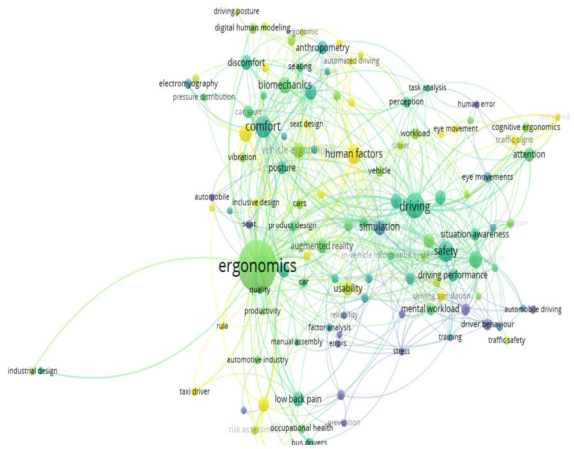

Fig. 4: Bibliometric networks regarding the ergonomics of the interior passenger compartment in VOSViewer

The ergonomics of the interior cabin is linked to a series of factors, different densities. The higher the density, the stronger the relationship between the factors. The bibliometric links were made using the VOSViewer software.

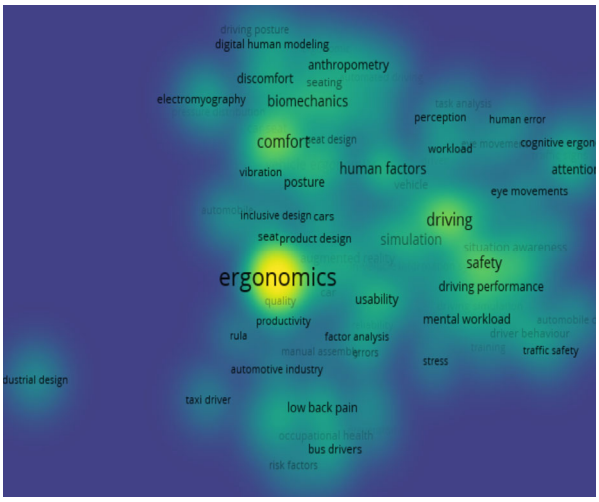

Fig. 5: The density of factors related to the ergonomics of the vehicle interior

The factor density is also done with the VOSViewer software.

Regarding the interior of the vehicle, the parameters that psychologically influence the pleasure of using the vehicle are: the degree to which the passenger compartment can be inhabited, accessibility, comfort, sensory pleasure offered, usability and external visibility.

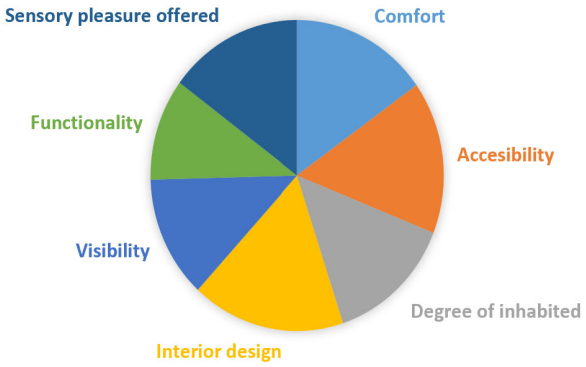

Fig. 6: Diagram of the influencing factors of the ergonomics of the interior passenger compartment

The degree to which the passenger compartment can be inhabited refers to the vehicle's ability to provide:

-postural comfort for the driver and passengers. The driver's position is conditioned by constraints imposed by the driving activity, which requires the actuation of the control organs (steering wheel, pedals, gear shift lever, switches, buttons, etc.), observation of the road, traffic and dashboard and constraints imposed by the rules of security (use of restraint systems). Passengers can be seated in different positions than the driver. Their position is conditioned by constraints imposed by security rules

and less by constraints imposed by the performance of certain activities (opening doors, windows, etc.).

-a sufficient necessary space, restricted by the different movements of the body, arms and legs, necessary to carry out specific activities. The degree to which the passenger compartment is habitable, as perceived by the driver and passengers, is a factor determined by the feeling of comfort given by the complex relationship between the dimensions of the vehicle's interior, the perception of the outside through the windshield and side windows, and the freedom of movement inside.

Accessibility refers to the ability to allow certain movements to be performed through minimal postural changes and maximum naturalness. For the upper part of the body, accessibility may be conditioned by the thickness of clothing and the presence of objects such as a bag or an umbrella. For the lower part of the body, accessibility may be conditioned by clothing (pants, skirt) and type of footwear.

Comfort refers to the well-being provided by a civilized, pleasant, comfortable and hygienic existence. This state of well-being derives from the reduction or absence of perceived disturbances. Comfort is a passive sensory concept, synonymous with convenience and has several components:

-vibrational comfort – the effects on the passengers of the vibrations induced by the operation of the engine and the movement of the vehicle on the roadway. The vibrational comfort is influenced by the characteristics of the support system of the engine group and the suspension system of the vehicle through which the vibrations are transmitted to the passenger compartment;

-acoustic comfort – the effects on the passengers of the noise produced by the operation of the various sub-assemblies and the movement of the vehicle (aerodynamic and running noise). Acoustic comfort is influenced by the sound-absorbing and sound-insulating characteristics of the walls and components of the passenger compartment;

- thermal comfort – the quality of the microclimate inside and the thermal sensation of contact with the interior surfaces;

Sensory pleasure refers to the quality perceived through the senses, which cannot be absolutely measured and which is valid for everyone and always. Sensory pleasure is an active and cognitive aspect that responds to expectations from a mental model and has several components:

-acoustic pleasure – the quality of the perception of the noises produced by the operation and movement of the vehicle, the noises produced by the handling of various components (opening and closing doors, actuation of switches, etc.) and artificial signaling and warning noises;

-tactile pleasure – the pleasure of contact between the human body and surfaces interiors. Tactile pleasure is influenced by the intensity and duration of contact, as well as the quality of the materials used; - visual pleasure – pleasure perceived as harmony or as meaning, through seeing shapes and colors;

-thermal pleasure – the sensation of hot or cold perceived through contact with the materials from which the interior surfaces are made;

-olfactory pleasure – the sensation perceived by the presence of pleasant smells.

Functionality is the ability of a system to perform its duties when used by the user in the operational environment. It refers to the efficiency and satisfaction with which different users can achieve specific goals in particular environments.

-visibility – the ability to visually distinguish stimuli from the environment and refers to the ability to identify command and control organs;

-legibility – the visual quality of the symbols, signs, indicators and graphic and descriptive indications of the control devices;

-intelligibility – the quality of the message transmitted by the control equipment and its interpretation by the user. Intelligibility depends on the experience, intellectual knowledge, cultural level and individual ability of each user;

- the ease of touch – the ease with which the various levers, switches or buttons used to control the operation of the system can be touched and depends on the posture and the anthropometric characteristics of the user;

-ease of operation – the characteristics of the controls to enable the user to achieve the desired results in an efficient and satisfactory manner. In this sense, the following must be analyzed: the way of operation (how they are grasped, handled and released, the number of fingers used, the direction of actuation, etc.), the ease of being grasped (shape, dimensions, softness, flexibility, etc.), perceived weight, force required for actuation and space required for grasping and handling;

-command feedback – the quality of the message conveyed by the complete actuation. It can have several components: visual feedback (indicator and warning lights with various symbols), acoustic feedback (significant actuation noises, artificial warning sounds, etc.) and immediate feedback (perception of complete actuation, perception of actuation completion).

External visibility refers to the field of vision outside the vehicle, perceived from the position of the driver and passengers. Visibility external has two components:

-field of direct and indirect visibility:

-directly – the external environment visible through the windshield and the side windows;

-indirect – the external environment visible through mirrors or video cameras;

- the quality of vision – influenced by the transparency of the windows and the windshield, the characteristics of the rainwater and mud wiping

system and the reflection of the dashboard lights on the windshield [11].

Improving the influencing factors of the ergonomics of the interior leads to improved driving performance. Direct action and direct measures taken to improve these factors can significantly reduce development costs and the development cycle of a new vehicle.

3.Ergonomics of the driving position

Anthropometry is the science closely related to ergonomics, based on the study of the human body and its dimensional evolution over time. This science is indispensable in the automotive industry because it establishes design requirements based on the anthropometric dimensions of the human body [12].

The issues related to the ergonomics of the driving position and the passenger compartment are not explicitly dealt with by the European Community directives on road vehicles which, in general, define the characteristics and performances of different types of vehicles, in order to ensure active and passive safety conditions or to comply with some limits regarding emissions of noxes. Given that the SAE (Society of Automotive Engineers) has regulations regarding the anthropometric standards for the dimensional connection between man and vehicle, car manufacturers have agreed to use common regulations, based on the SAE regulations (ECIE European Norms - European Car Manufacturers Information Exchange Group) [13].

The driver's seat is ergonomically designed, in accordance with the international standards in force: SAE J826, SAE J941, SAE J1050, SAE J1052, SAE J1100, ISO 3411, ISO 15535, SR.ISO 3409, SR.ISO 3958, STAS 6681, STAS 12613 The main requirements taken into account in the design of the driving position are: the main anthropometric dimensions of the passengers, the shape and location of the driver's seat, the dimensions, shape and location of the control devices, the optimal visual field for the driver [14, 15].

The main SAE standards used in testing the ergonomics of the driver's driving position are also, SAE J 287 - for the positioning of the main controls, SAE J 941 - for the position of the driver's eyes, SAE J 1052 - for the position of the driver's head, SAE J 1517 – for the driver's seat position.

In conclusion, the driver's position can be a relaxing one, with low energy consumption and satisfying postural comfort conditions, if the elements of the driving position are sized and placed correctly.

Fig. 7: Model in the ergonomic testing of the passenger compartment for the driver of the vehicle [14]

5. Conclusions

Evaluating the influencing factors of the ergonomics of the interior cabin is an expensive process in terms of time and resources that must be made available, it is also a process that must be taken into account from the vehicle design phase. This study aims to make cumulative preliminary estimates for the influencing factors of the ergonomics of the interior cabin, analyzed objectively, in order to obtain an initial picture of the cumulative impact of the ergonomics of the cabin on the overall performance of the vehicle. The factors with high influence were decisive: the degree to which the passenger compartment can be inhabited, accessibility, comfort, sensory pleasure offered, usability and external visibility, which have a particular impact on the ergonomics of the interior of the vehicle body, objectively, by establishing bibliometric networks in VOSViwer software.

The paper presents a strategy for the objective determination of important data regarding the ergonomics of the vehicle cabin, together with the selection of the best available techniques, with the aim of contributing to the improvement of the current vehicle performance requirements.

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